Upper Patuxent River

2018 Sediment TMDL Annual Assessment Report

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Prepared For

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List of Acronyms

BayFAST	Chesapeake Bay Facility Assessment Scenario Tool
BMP	Best Management Practices
BSID	Biological Stressor Identification
CAST	Chesapeake Assessment Scenario Tool
CBP	Chesapeake Bay Program
CIP	Capital Improvement Program
DPW	Department of Public Works
EOS	Edge of Stream
MAST	Maryland Assessment Scenario Tool
MDE	Maryland Department of the Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
SPSC	Step Pool Storm Conveyance
SW to MEP	Stormwater to the Maximum Extent Practicable
SW-WLA	Stormwater Wasteload Allocation
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
EPA	United States Environmental Protection Agency
WLA	Wasteload Allocation
WPRP	Watershed Protection and Restoration and Program

1 Introduction

1.1 Background

The Anne Arundel County Department of Public Works (DPW) Watershed Protection and Restoration Program (WPRP) has developed and is currently implementing, restoration plans to address local water quality impairments for which a Total Maximum Daily Load (TMDL) has been established by the Maryland Department of the Environment (MDE) and approved by the U.S. Environmental Protection Agency (EPA) (MDE, 2011). A TMDL establishes a maximum load of a specific single pollutant or stressor that a waterbody can assimilate and still meet water quality standards for its designated use class.

There are currently four final TMDLs in the Upper Patuxent for which Anne Arundel County has some responsibility; total suspended solids (TSS; sediment) and bacteria TMDLs were all approved in 2011, and a Polychlorinated Biphenyls (PCB) TMDL was approved in 2017. These TMDLs apply to several jurisdictions including Howard, Prince George's, and Anne Arundel Counties. Anne Arundel County WPRP developed a TMDL restoration plan for the sediment TMDL, drafted in 2015 and finalized in November of 2016 (Anne Arundel County, 2016) after review and comment from MDE and the general public. The plan specifically addresses the Upper Patuxent sediment TMDL under the responsibility of Anne Arundel County. The bacteria and PCB TMDLs are addressed by Anne Arundel County in separate plans.

Responsibility for Upper Patuxent sediment reduction is divided among the contributing jurisdictions, listed above. The TMDL loading targets, or allocations, are also divided among the pollution source categories, which in this case includes non-point sources (termed load allocation or LA) and point sources (termed waste load allocation or WLA). The WLA consists of loads attributable to regulated process water or wastewater treatment, and regulated stormwater, which is the stormwater wasteload allocation (SW-WLA). For the purposes of the TMDL and consistent with implementation of the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit (MS4), stormwater runoff from MS4 areas is considered a point source contribution.

Anne Arundel County's current MS4 permit (11-DP-3316, MD0068306) issued in its final form by the MDE in February of 2014 required development of restoration plans for each SW-WLA approved by EPA prior to the effective date of the permit (permit section IV.E.2.b), and requires an annual TMDL assessment report to document progress with implementation, pollutant load reductions, and program costs (permit section (IV.E.4). The *Upper Patuxent River Sediment TMDL Restoration Plan* (the plan) (Anne Arundel County, 2016) satisfied the permit planning requirement and this *2017 Upper Patuxent River Sediment TMDL Annual Assessment Report* satisfies the progress documentation requirement.

1.2 Watershed Description

The Upper Patuxent is one of 12 major watersheds in Anne Arundel County, Maryland, and is situated in the western portion of the County (Figure 1). The watershed shares political boundaries with Prince George's County along the Patuxent River and a smaller portion of the watershed is shared with Howard County. The Upper Patuxent watershed is a part of the Chesapeake Bay watershed with the Patuxent River mainstem discharging directing into the Chesapeake Bay. Anne Arundel County's portion of the Upper Patuxent watershed is approximately 22,420 acres (35.0 square miles) in area and contains approximately 90 total perennial miles of stream reaches. The watershed includes several named streams including Stocketts Run, Davidsonville Branch, Ropers Branch, and the mainstem of the Upper Patuxent River. The watershed includes portions of the Patuxent Wildlife Refuge (Figure 1).

Figure 1: Watershed Location Map

1.3 TMDL Allocation and Planned Loads Summary

This section describes the derivation of the TMDL reduction targets. SW-WLAs in the sediment TMDL were developed using the Chesapeake Bay Program Phase 5 (CBP P5) watershed model. In development of the Upper Patuxent Plan in 2015-2016, BayFAST (Chesapeake Bay Facility Assessment Scenario Tool) was used in the modeling. See section 1.5 below for more details on the modeling specifics. BayFAST, during plan development, was compatible with an updated version of the model: CBP P5.3.2. Because the TMDL was developed under an older version of the model, the SW-WLA needed to be translated into a BayFAST-compatible target load. In order to do this, the 2005 baseline sediment load was re-calculated in BayFAST by modeling baseline BMPs in the Upper Patuxent on top of baseline impervious and pervious Anne Arundel County Phase I MS4 acres.

The required reduction percent assigned to the Anne Arundel County Phase I MS4 source (11.4%) in the local TMDL regulation was then applied to the new baseline load to calculate required sediment reduction. The required sediment reduction was then subtracted from the new baseline load to calculate the BayFAST-compatible target SW-WLA are shown in Table 1.

Table 1: Sediment Loads Required for the Upper Patuxent River Local TMDL

2005 Baseline Load (lbs/yr)	Required Reduction %	Required Reductions (lbs/yr)	TMDL Load Allocation (SW-WLA) (lbs/yr)
485,565	11.4%	55,354	430,211

Since development of the final plan in late 2016, Phase 6 of the Bay model has been developed and is currently being deployed in the Chesapeake Assessment Scenario Tool (CAST). BayFAST function was ended in early 2018 and not available for modeling FY2017 progress; therefore, FY2017 progress was modeled using the Maryland Assessment Scenario Tool (MAST), which is compatible with BayFAST and built on Bay model version P5.3.2. For the purposes of this FY2018 annual progress report, MAST was used again for consistency. MAST availability will end in early 2019 and future progress modeling will be revised to reflect Phase 6 updates in CAST.

1.4 Planned Reductions

This section includes a summary of the reductions that were presented in the 2016 Upper Patuxent Plan, with modifications based on a change in implementation levels that was discovered during the 2016 progress modeling and submitted to MDE with the FY2016 annual report.

This section includes a summary of the reductions that were presented in the Upper Patuxent River Plan (Anne Arundel County, 2016). Table 2, provides a concise summary of the loads and reductions at important timeline intervals including the 2005 baseline, 2015 progress, 2017 milestone and 2025 final planning intervals. These terms and dates are used throughout the plan and explained in more detail in the following sections. They are presented here to assist the reader in understanding the definitions of each, how they were derived, and to provide an overall summary demonstrating the percent reduction required and percent reduction achieved through full implementation of this plan. Sediment loads and wasteload allocations are presented as tons/year in the *Total Maximum Daily Load of Sediment in the Upper Patuxent River Watershed, Anne Arundel, Howard and Prince George's Counties, Maryland* but will be discussed as lbs/year in this report. All loads presented below were calculated in BayFAST.

- **2005 Baseline Loads**: Baseline levels (i.e., land use loads with baseline BMPs) from 2005 conditions in the Upper Patuxent watershed. Baseline loads were used to calculate the stormwater allocated sediment loads, or SW-WLA.
- **2015 Progress Loads and Reductions**: Progress loads and load reductions achieved from stormwater best management practice (BMP) implementation through 2015. The 2015 Progress Loads are calculated from the 2005 Baseline Loads by the following calculations: 2015 Progress Load = 2005 Baseline – 2015 Progress Reduction.
- **2017 Interim Milestone Planned Loads and Reductions**: Planned 2017 loads and reductions will result from implementation of strategies through 2017. The 2017 Planned Loads are calculated from the 2005 Baseline Loads by the following calculation: 2017 Progress Load = 2005 Baseline – 2017 Planned Reduction.
- **2025 Allocated Load**: Allocated loads are calculated from the 2005 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 2025 Allocated Load = 2005 Baseline – (2005 Baseline x 0.205).
- **2025 Planned Loads and Planned Reductions**: Loads and reductions that will result from implementation of this plan. The 2025 Planned Loads are calculated from the 2005 Baseline Loads by the following calculation: 2025 Planned Load = 2005 – 2025 Planned Reduction.

Table 2: Upper Patuxent Local TMDL Allocated and Planned Loads

	Sediment (tons/year)	Sediment (lbs/year)
2005 Baseline Loads	243	485,565
2015 Progress Loads	226	451,147
2015 Progress Reductions	17	34,418
2017 Planned Loads*	217	434,072
2017 Planned Reductions	26	51,493
2025 TMDL Allocated Loads	215	430,211
2025 Planned Loads*	190	379,634
2025 Planned Reductions	53	105,931
Required Percent Reduction	11.4%	11.4%
Planned Percent Reduction	21.8%	21.8%

*2017 and 2025 planned loads are calculated by subtracting planned restoration sediment reductions from the 2005 Baseline Load. It is assumed that all new development will be treated with SW to the MEP implementation to achieve 90% sediment removal and Accounting for Growth policies will address the remaining 10%.

1.5 Modeling Methods

1.5.1 Overview

Each BMP provides a reduction for nitrogen, phosphorus, and sediment, along with other pollutants. The pollutant load for the Upper Patuxent watershed was determined using BayFAST, which calculates pollutant loads and reductions calibrated to the Chesapeake Bay Program Partnership Watershed Model. BayFAST, created by Devereux Environmental Consulting for MDE, is a web-based pollutant load-estimating tool that streamlines environmental planning. BayFAST allows users to specify, delineate facility boundaries (e.g., watershed, parcel, drainage area), and alter land use information within the delineated boundary depending on the model year. Local TMDL baseline loads were calibrated in BayFAST by modeling BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. This ensures that the same set of baseline BMPs are used throughout future progress and planned scenarios. The target sediment load (i.e., local SW-WLA) was calculated by multiplying the local TMDL target reduction percent with the BayFAST baseline load to first calculate a calibrated reduction target. This reduction target was then subtracted from the baseline load modeled in BayFAST.

The County previously used BayFAST to model progress loads; however, the BayFAST model was shut down in early 2018. This year, the County used MAST as an alternative method for modeling fiscal year 2018 progress loads. Load reductions for restoration BMPs with a built date between 7/1/2017 and 6/30/2018, inclusive, were modeled in MAST. The fiscal year 2018 load reductions were then subtracted from the progress loads reported in the County's 2017 annual assessment report to calculate fiscal year 2018 progress loads.

BayFAST and MAST both estimate load reductions for point and nonpoint sources including agriculture, urban, forest, and septic loading. Load reductions are not tied to any single BMP, but rather to a suite of BMPs working in concert to treat the loads. BayFAST, MAST, and the Chesapeake Bay Program Partnership Watershed Model calculate reductions from all BMPs as a group, much like a treatment train. Reductions are processed in order, with land use change BMPs first, load reduction BMPs next, and BMPs with individual effectiveness values at the end. The overall the load reduction can vary depending on which BMPs are implemented.

Pollutant load reductions achieved by annual based maintenance efforts (e.g., street sweeping and inlet cleaning) are calculated outside of MAST. Sediment reduction credit for vacuum-assisted street sweeping and inlet cleaning is calculated following methods described in MDE (2014b) based on the mass of material removed.

Both the Chesapeake Bay Program Partnership Watershed Model and BayFAST/MAST provide loads at two different scales: Edge-of-Stream (EOS) and Delivered (DEL). Delivered loads show reductions based on in-stream processes, such as nutrient uptake by algae or other aquatic life. This TMDL plan focuses on reducing load on the land, so EOS estimates are more appropriate and are used for all the modeling analysis.

1.5.2 Practice Level

This section briefly describes each practice and includes a summary of the typical sediment reductions achieved with each type.

1.5.2.1 Modeled in MAST

- **Bioretention** — An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants. Rain gardens may be engineered to perform as a bioretention.
- **Bioswales** —An open channel conveyance that functions similarly to bioretention. Unlike other open channel designs, there is additional treatment through filter media and infiltration into the soil.

- **Dry Detention Ponds** – Depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow. BayFAST/MAST modeling includes hydrodynamic structures in this category. These devices are designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
- **Dry Extended Detention Ponds** - Depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. They are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, allowing additional wet sedimentation to improve treatment effectiveness.
- **Impervious Surface Reduction** - Reducing impervious surfaces to promote infiltration and percolation of runoff storm water. Disconnection of rooftop and non-rooftop runoff, rainwater harvesting (e.g., rain barrels), and sheetflow to conservation areas are examples of impervious surface reduction.
- **Infiltration** — A depression or trench to form a shallow basin where sediment is trapped and stormwater infiltrates into the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be built in good soil; they are not constructed on poor soils, such as C and D soil types. Yearly inspections to determine if the basin or trench is still infiltrating runoff are planned. Dry wells, infiltration basins, infiltration trenches, and landscaped infiltration are all examples of this practice type.
- **Outfall Enhancement with Step Pool Storm Conveyance (SPSC)** – The SPSC is designed to stabilize outfalls and provide water quality treatment through pool, subsurface flow, and vegetative uptake. All County SPSCs are completed at the end of outfalls, prior to discharging to a perennial stream. The retrofits promote infiltration and reduce stormwater velocities. This strategy is modeled in BayFAST/MAST as bioswales.
- **Outfall Stabilization** – Restoration of outfalls using design approaches including rip-rap, riffle run sequences, step-pools and other grade and bank stabilization measures. These stabilization practices are modeled as stream restoration.
- **Urban Stream Restoration -** Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams.
- **Stormwater Retrofits –** Anne Arundel County plans to construct a variety of retrofits throughout the County. Stormwater retrofits may include converting dry ponds, dry extended detention ponds, or wet extended detention ponds into wet pond structures, wetlands, infiltration basins, or decommissioning the pond entirely to install SPSC (step pool storm conveyance).
- **Urban Filtering** - Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
- **Urban Tree Plantings** - Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting

- **Vegetated Open Channels** - Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.
- **Wet ponds or wetlands** — A water impoundment structure that intercepts stormwater runoff then releases it at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached pollutants. Until 2002 in Maryland, these practices were generally designed to meet water quantity, not water quality objectives. There is little or no vegetation within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal, but phosphorus and sediment are reduced.

The measured effectiveness for each of these practices are found in Table 3.

Table 3: Typical Sediment Reduction from Stormwater BMPs and Restoration Practices

BMP	Sediment Reduction
Bioretention A/B soils	80%
Bioretention C/D soils	55%
Bioswales	80%
Dry Detention Ponds	10%
Dry Extended Detention Ponds	60%
Impervious Surface Reduction[1]	-
Infiltration	95%
Outfall Enhancement with SPSC[2]	80%
Outfall Stabilization	44.9 lbs/linear ft
Stream Restoration	44.9 lbs/linear ft
Urban Filtering	80%
Urban Tree Plantings[1]	-
Vegetated Open Channels	70%
Wet Ponds or Wetlands	60%
Inlet Cleaning	420 lbs/ton removed
Inlet Cleaning	420 lbs/ton removed

Sources: Simpson and Weammert, 2009; and BayFAST/MAST documentation

[1] Calculated as a land use change to a lower loading land use

[2] Outfall enhancement with SPSC modeled as bioswales in BayFAST/MAST

[3] Outfall stabilization and stream restoration listed with revised interim rate; specific stream restoration projects now use Bay Program Protocols however streams and outfalls for this assessment are modeled in BayFAST/MAST.

1.5.2.2 Modeled using MDE Guidance

Along with the structural BMPs listed above, treatment will also be provided through non-structural measures. These are treatments that rely on programs that continue throughout the year and are repeated annually. Both are calculated using MDE's accounting guidance (MDE, 2014b).

- **Inlet Cleaning -** Storm drain cleanout practice ranks among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their NPDES stormwater permits. Sediment reduction credit is based on the mass of material collected, at the rate of 420 lb TSS per ton of wet material (MDE, 2014b).

Data for the mass removed from each cleaned inlet was reported from the County's Bureau of Highways. The total mass of material collected by the inlet cleaning program each year is distributed proportionately across all of the inlets cleaned and then summed at the watershed scale. Summed mass totals per year for each watershed were then averaged across all available years of data (FY2017-FY2018). The County's inlet cleaning program is now at maturity and while amounts of material collected each year may vary, the current level of effort will be maintained in the foreseeable future.

- **Street sweeping** — Starting Fiscal Year 2015, Anne Arundel County enhanced their street sweeping program which now includes sweeping curb-miles and parking lots within the Little Patuxent (Anne Arundel County DPW, 2015; Figure 2). This enhanced program targets impaired watersheds and curbed streets that contribute trash/litter, sediment, nutrients, and other pollutants. Load reductions for this assessment are calculated using the material collected, at the rate of 420 lb TSS per ton of wet material (MDE, 2014b). Data for the mass removed was reported from the County's Bureau of Highways. The total mass of material collected by the street sweeping program each year is distributed proportionately across all of the roadway segments swept and then summed at the watershed scale. Summed mass totals per year for each watershed were then averaged across all available years of data (FY2016-FY2018). The County's street sweeping program is now at maturity and while amounts of material collected each year may vary, the current level of effort will be maintained in the foreseeable future.

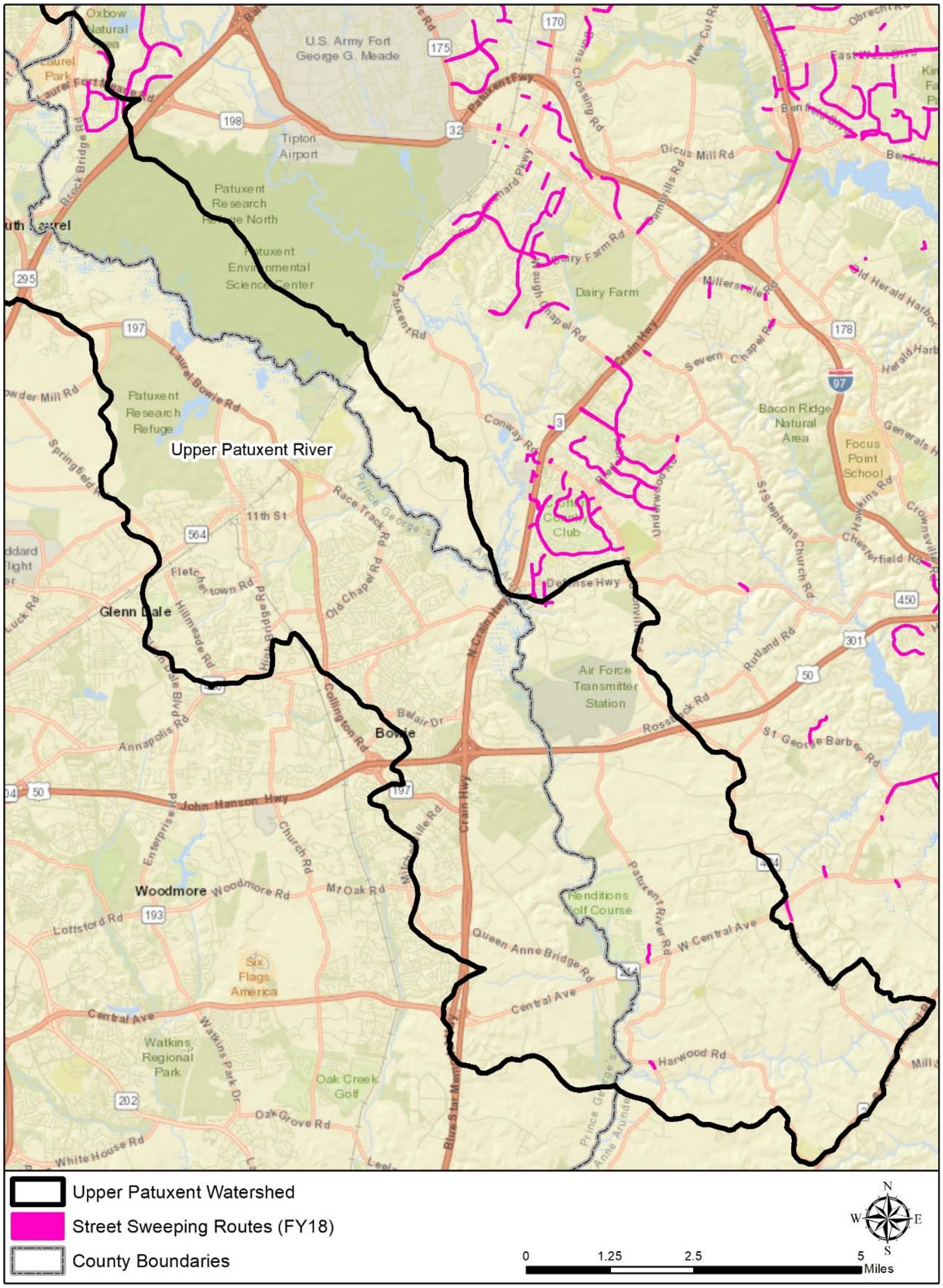

Figure 2: Street Sweeping Routes in Upper Patuxent Watershed, Anne Arundel County, Maryland

2 2018 Progress Summary

The following section summarizes the County's implementation efforts, the resulting load reductions achieved, and the costs of program implementation.

2.1 Implementation Results

Implementation up through the end of fiscal year 2018 is detailed in Table 4. Information on completed projects and programs is gleaned primarily from the County's MS4 geodatabase. All 2018 implementation is included in the database. Additional pre-2016 restoration projects were pulled from the County's geodatabase of stormwater urban BMP facilities and water quality improvement projects (WQIP). In 2018 the County completed a comprehensive record review of stormwater BMPs. The County's MS4 Geodatabase has been updated to incorporate the results of the review.

No restoration projects were completed during FY2018.

Inlet Cleaning
A total of seven inlet cleaning records using storm drain vacuuming were recorded in FY2018.

Street Sweeping
Building upon the County's enhanced street sweeping program, 8.5 curb miles were swept in the watershed during FY2018. The total mass of material collected by the street sweeping program during that period was 6.67 tons. Total mass reported for FY2018 is the average of annual mass removed for FY2016 through FY2018.

The total cost of the practices and programs implemented in FY2018 is $12,654.

Table 4: Current BMP Implementation through FY2018

BMP	Unit	2005 Baseline	2006 - 2015 Restoration[2]	2016 Restoration[2]	2017 Restoration[2]	2018 Restoration[2]	2018 Progress[3]	2018 Restoration Cost[4]
Structural Permanent Practices								
Bioretention	acre	0.0	0.1	0	0	0	0.1	NA
Bioswale	acre	4.0	0	0	0	0	4.0	NA
Dry Ponds	acre	52.6	0	0	0	0	0	NA
Extended Detention Dry Ponds	acre	13.6	0	0	0	0	0	NA
Impervious Surface Reduction	acre	0.0	0.1	0	0	0	0.1	NA
Infiltration	acre	255.0	0	0	0	0	0	NA
Urban Filtering	acre	0	0	0	0	0	0	NA
Stormwater Retrofits[1]	acre	0	0	0	0	0	0	NA
Vegetated Open Channels	acre	0	0	0	0	0	0	NA
Wet Ponds or Wetlands	acre	159.9	22.3	0	0	0	22.3	NA
Urban Stream Restoration	linear ft	0	1,950.0	0	0	0	1,950.0	NA
Outfall Stabilization	linear ft	0	0	0	0	0	0	NA
Outfall Enhancement with SPSC	acre	0	0	0	0	0	0	NA
Annual Practices								
Inlet Cleaning[5]	inlets/yr	0	38	NA	2	7	7	$6,069
Street Sweeping[6]	lbs /yr	0	NA	NA	26,170	13,336	13,336	$6,585
							Total FY2018 Cost	$12,654

Source: WPRP urban BMP, WQIP and MDE MS4 FY2018 geodatabase

[1] Includes projects that convert dry ponds into wet ponds. Stormwater retrofits are modeled by decreasing acreage for dry ponds and increasing acreage for wet ponds.

[2] Restoration completed in each specific period, i.e. 2006-2015, 2017 and 2018.

[3] Total cumulative restoration accounting for the full 2005-2018 period.

[4] Cost of projects and programs for the 2018 period only. Only costs using County funds are included.

[5] Number of inlets refers to the number of inlet cleaning records from the County's MS4 geodatabase.

[6] Value listed here is the lbs of material removed, not specifically the fine TSS sediment; FY2018 is the average of annual reported values for FY2016 through FY2018.

2.2 Load Reduction Results

The implementation summarized in Table 4 above resulted in the load reductions presented here in Table 5. Reductions in 2018 were lower than those reported in the previous 2017 period due to a decrease in the amount of material removed and thus TSS reduced from street sweeping (-2,695 lbs; 49.0%) but an increase in the reduction from inlet cleaning (162 lbs; 148%) during this reporting period when compared to FY2017 for a net change of -2,533 lbs.

Of the 35,114 lbs of progress reduction achieved through FY2018, 2,801 lbs (8.0% of the total reduction) are being removed by street sweeping, and 272 lbs (0.8%) are accounted for by inlet cleaning. The remainder is being reduced by the suite of restoration projects.

Table 5: 2018 Progress Reductions Achieved

Baseline Load and TMDL SW-WLA	TSS-EOS lbs/yr
2005 Baseline Scenario Load	485,565
Required Percent Reduction	11.4%
Required Reduction	55,354
Local TMDL SW-WLA	430,210
2015 Results	**TSS-EOS lbs/yr**
2005-2015 Load Reduction	34,418
2005-2015 Load Reduction Percent	7.1%
Progress Scenario Load	451,147
Progress Reduction Achieved	34,418
Percent Reduction Achieved	7.1%
2016 Results	**TSS-EOS lbs/yr**
2016 Load Reduction	-49
2016 Load Reduction Percent	-0.01%
Progress Scenario Load	451,196
Progress Reduction Achieved	34,369
Percent Reduction Achieved	7.1%
2017 Results	**TSS-EOS lbs/yr**
2017 Load Reduction	3,278
2017 Load Reduction Percent	0.7%
Progress Scenario Load	447,918
Progress Reduction Achieved	37,647
Percent Reduction Achieved	7.8%
2018 Results	**TSS-EOS lbs/yr**
2018 Load Reduction	3,073
2018 Load Reduction Percent	0.6%
Progress Scenario Load	450,451
Progress Reduction Achieved	35,114
Percent Reduction Achieved	7.2%

3 2018 Progress Comparison

This section describes the current progress of both implementation and load reductions with comparison to the planned totals and the progress that was expected by 2018.

3.1 Implementation

Table 6 compares implementation of existing restoration BMPs up through fiscal year 2018 (2018 Progress) with the total planned levels of implementation that were derived in the initial plan (Anne Arundel County, 2016). Progress was made for several strategies in the initial 2006-2015 period (e.g. bioretention, wet ponds) and street sweeping is continuing at 173% of the initially prescribed rate.

Implementation of wet ponds/wetlands and stream restoration projects are on-going and at 50% of the planned target. SPSC and filtering projects have thus far not been completed.

Estimates of inlet cleaning in the development of the plan were based on the total number of inlets cleaned Countywide with estimates based on the numbers of inlets in each watershed and assumptions of the average sediment yield from each inlet cleaned. The plan then called for a level of treatment consistent with the progress rate of 38 inlets per year. The actual number cleaned in the current reporting period is 7. This current level of inlet cleaning is removing 25.8% of the material estimated to be removed annually in the restoration plan.

Table 6: Restoration BMP Implementation - Current 2018 and Planned 2025 Implementation Levels

BMP	Units	Total Planned Restoration	2018 Progress	Percent Complete
Bioretention	acre	0	0.1	NA
Bioswale	acre	0	0	NA
Dry Ponds	acre	0	0	NA
Extended Detention Dry Ponds	acre	0	0	NA
Impervious Surface Reduction	acre	0	0.1	NA
Infiltration	acre	0	0	NA
Urban Filtering	acre	10.0	0	0%
Stormwater Retrofits	acre	0	0	NA
Vegetated Open Channels	acre	0	0	NA
Wet Ponds or Wetlands	acre	44.5	22.3	50%
Urban Stream Restoration	linear feet	3,200	1,950	61%
Outfall Stabilization	linear feet	0	0	NA
Outfall Enhancement with SPSC	acre	201.9	0	0%
Annual Practices				
Inlet Cleaning	inlets/yr	38	7	18%
Street Sweeping	curb-miles	4.9	8.5	173%

To track progress, the 2025 implementation milestone first reported in the 2016 plan was compared against the 2018 progress reported here in this assessment. Table 7 presents the strategies that were planned for the 2018-2025 milestone period with a comparison to the practices that were completed for 2018.

Street sweeping continues at 173% of the prescribed rate with small amounts of inlet cleaning also completed in the period. Inlet cleaning appears to be lower than planned, but measured mass removed from inlets shows a much larger removal of material than was initially planned for in the restoration plan. The street sweeping and inlet cleaning programs are at maturity and will be maintained at this level of effort in the foreseeable future

Table 7: Implementation Milestones Comparison

BMP	Unit	2018-2025 Planned	2018 Actual	Percent Complete
Urban Stream Restoration	linear feet	800	0	0%
Outfall Enhancement with SPSC	acre	175.2	0	0%
Annual Practices				
Inlet Cleaning	no. of inlets/yr	38	7	18.4%
Street Sweeping	curb miles	4.9	8.5	173%

Currently Anne Arundel County is in the design phase for the Maryland City Outfall and Stream Restoration project which is slated for construction for winter 2019-2020. The project includes three SPSCs with a combined 69 acre drainage area and restoration of several stream reaches totaling over 2,500 feet.

3.2 Load Reductions

This section compares the required and planned sediment load reductions against the progress made through fiscal year 2018. Values given in Table 8 include the load reductions for each period (generally the milestone years) and the resulting load. Both the planned results and the actual results are shown for the 2015, 2016, and 2017 periods and the actual results are shown for 2018. All values shown (reductions, loads, percent reduction) are the cumulative values, not the year over year changes.

Overall, the results indicate that on a TMDL allocated goal of 11.4%, the County has achieved a 7.2% reduction, which translates to 63% progress towards the reduction goal. The 2016 plan (Anne Arundel County, 2016) anticipated 10.6% reduction by 2017. With no additional planned milestones to help gauge progress, the additional reduction needed between the actual 2017 reduction and the final 2025 reduction of 11.4% was converted to a reduction per year (2,213 pounds or 0.45%) assuming an even distribution of restoration projects over time. When compared to the 2018 reduction of 7.2% the current progress is behind by 4,746 pounds.

The County's initial estimate and plan were based on a 2025 end date for meeting the TMDL. Although the progress as of FY2018 is slightly behind schedule, the overall program is on track to meet the end date ahead of schedule with completion of a small number of restoration projects and continued street sweeping and inlet cleaning as prescribed.

The Maryland City Outfall and Stream Restoration project, based on early calculations at the 30% design phase, is estimated to reduce over 400 tons of sediment. Once the project is finalized, the load reductions will be updated and compared to the target goals. The project is expected to make substantial progress towards the final goal.

Table 8: Planning and Target Sediment Load Comparison (lbs/year)

Milestone Year	Planned Load Reduction	Planned Load	Planned % Reduction From Baseline	Actual Load Reduction	Actual Load	Actual % Reduction from Baseline
2005 Baseline	-	-	-	-	485,565	-
2015 Progress	-	-	-	34,418	451,147	7.1%
2016 Progress	-	-	-	34,369	451,196	7.1%
2017 Planned and Progress	51,493	434,072	10.6%	37,647	447,918	7.8%
2018 Progress	-	-	-	35,114	450,451	7.2%
2025 Allocated	55,354	430,211	11.4%	-	-	-
2025 Planned	105,931	379,634	21.8%	-	-	-

4 Monitoring

Official monitoring for Integrated Report assessments and impairment status is the responsibility of the State; however, the County has many on-going monitoring programs that can support the State's efforts. In addition, MDE has stressed specifically for sediment impairments the connection between in-stream biological health and meeting the intent of the sediment TMDL goals.

To determine the specific parameters to be monitored for tracking progress, one must understand the approach used for the initial listing. The Upper Patuxent was originally listed for sediments in 1996 as a total suspended solids/sediment listing. In 2002, the State began listing biological impairments on the Integrated Report, at the 8-digit scale, based on a percentage of stream miles degraded and whether they differ significantly from a reference condition watershed (<10% stream miles degraded). The biological listing is based on Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) results from wadeable streams from assessments conducted by the Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (MBSS). The Upper Patuxent was listed for biological community impairment in 2006.

MDE then utilized its Biological Stressor Identification (BSID) process to identify the probable or most likely causes of poor biological conditions. For sediment specifically, the BSID identified 'altered hydrology and increased urban runoff have resulted in degradation to streambed morphology, streambed scouring, and subsequent elevated suspended transport through the watershed.' Overall, the results indicated inorganic pollutants (i.e. chlorides, acute ammonia, sulfate), and flow/sediment related stressors as the primary stressors causing impacts to biological communities.

Based on the results of the BSID (MDE, 2010), MDE replaced the biological impairment listing with a listing for total suspended solids (TSS). The 2012 and 2014 integrated reports (MDE, 2012a and MDE, 2014a) lists 'Habitat Evaluation' as the indicator, and urban runoff/storm sewers as the source. It is noted that the *Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012)*[1], makes a specific distinction between two different, although related 'sediment' impairment types in free flowing streams:

1. **TSS**: The first type is an impact to water clarity with impairment due to TSS using turbidity measured in Nephelometer Turbidity Units (NTUs). Although numeric criteria have not been established in Maryland for TSS, MDE uses a threshold for turbidity, a measurement of water clarity, of a maximum of 150 Nephelometer Turbidity Units (NTU's) and maximum monthly average of 50 NTU as stated in Maryland COMAR regulations (26.08.02.03-3). Turbidity also may not exceed levels detrimental to aquatic life in Use I designated waters.
2. **Sedimentation / siltation**: The second type is an impact related to erosional and depositional impacts in wadeable streams. The measures used are biocriteria and the critiera for Use I streams (the protection of aquatic life and growth and propagation of fish (other than trout) and other aquatic life).

With these two sediment impairments in mind the Upper Patuxent, which is listed as impaired for TSS, would seem to be water clarity issue; however the methodology used for listing (biological and habitat

[1] http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

measures related sediment deposition) seems to point to an in-stream sediment deposition problem. In all likelihood both types of impairment, water clarity and sedimentation, are factors and both should be incorporated into monitoring programs to track changes in the watershed condition over time.

Anne Arundel County's Watershed Protection and Restoration Program (WPRP) has several on-going monitoring programs that target measures of water clarity and sedimentation. These programs are described here.

4.1 Countywide Biological Monitoring

4.1.1 Background and Goals

Biological monitoring and assessment provide a direct measure of the ecological health of a stream. Stream organisms are continuous monitors of both short- and long-term water quality and other environmental factors and provide direct indicators of the quality of a stream. Advantages of using benthic macroinvertebrates include their generally restricted mobility and often multi-year life cycles, allowing them to integrate the effects of both chemical and physical perturbations over time. When hydrologic regimes of streams are altered, the physical nature of the habitat changes due to accelerated erosion and deposition of channel soils and other materials. This changes the capacity of a stream to support a healthy biota. Changes in the quality of the water resource are reflected as changes in the structural and functional attributes of the macroinvertebrate assemblage. Biological monitoring and assessment results can be used to detect impairment of the biological community and to assess the severity of impacts from both point source (PS) and nonpoint source (NPS) pollution. When coupled with information on chemical and physical stressors, these types of exposure-and effect data can be used to improve water quality assessments. Over the past several decades, biological monitoring and assessment of aquatic communities along with characterization of their chemical and physical habitats have increased with application of these data to watershed management policies and practices.

Historically, many municipalities have been hampered in their ability to recommend and implement pollution control and remediation efforts because the chemical, physical, and biological condition of most of their water resources have not been adequately characterized. To expand its monitoring program, Anne Arundel County developed a stream monitoring program consisting of chemical, physical, and biological assessment techniques to document and track changes in the condition of stream resources County-wide. Problems resulting from chemical contamination and physical habitat alteration are reflected by changes in the aquatic biota. Therefore, inclusion of a biological monitoring component is providing Anne Arundel County with the relevant indicators for assessing the condition of, and managing, its water resources.

In 2004, a Countywide Biological Monitoring and Assessment Program for Anne Arundel County, Maryland was developed to assess the biological condition of the County's streams at multiple scales (i.e., site-specific, primary sampling unit (PSU), and countywide). Under the Countywide Biological Monitoring and Assessment program, biology (i.e., benthic macroinvertebrates) and stream habitat, as well as geomorphological and water quality parameters, are assessed at approximately 240 sites throughout the entire County over a 5-year period using a probabilistic, rotating-basin design.

Round 1 of the County's Biological Monitoring and Assessment Program occurred between 2004 and 2008, and Round 2 took place between 2009 and 2013. During 2017, Round 3 monitoring was initiated and fish sampling and additional water quality parameters were added. Field data collection was completed and analysis is currently underway. Annual reports and Round summary reports are available for review at: http://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and-evaluation/biological-monitoring/biological-monitoring-reports/index.html

The primary goals of the program are to assess the current status of biological stream resources, establish a baseline for comparison with current and future assessments, and to relate them to specific programmatic activities. The County currently uses a combination of chemical sampling, geomorphic assessment, storm water sampling, and biological sampling to assist in its environmental management decision-making process. This combination of monitoring greatly assists the County in assessing progress toward achieving Stormwater Wasteload allocations set forth in Sediment TMDLs. The biological monitoring program's stated goals are applicable at three scales; Countywide, Watershed-wide, and Stream-specific, and include the following components.

- Status: describe the overall stream condition
- Trends: how has the overall stream condition changed over time
- Problem identification/prioritization: identify the impaired and most degraded streams
- Stressor-response relationships: identify anthropogenic stressors and their biological response
- Evaluation of environmental management activities: monitor the success of implemented programs and restoration/retrofit projects

4.1.2 Methods

Both field sampling and data analysis methods were developed for the program to be directly comparable to Department of Natural Resources' Maryland Biological Stream Survey (MBSS), and complementary to those in place in Prince George's, Montgomery, and Howard Counties in Maryland (Hill and Stribling, 2004). Primary data collected include site location (latitude and longitude), pH, dissolved oxygen, water temperature and conductivity, benthic macroinvertebrate index of biotic integrity (BIBI), and physical habitat index (PHI) following MBSS methodologies (Kazyak, 2001; DNR, 2007) and EPA's Rapid Bioassessment Protocol (EPA RBP). Biological data were analyzed using the revised (2005) version of the MBSS Coastal Plain BIBI (Southerland et al., 2005).

A more detailed description of the sampling and analysis methods can be found in the annual Biological Monitoring and Assessment Program Annual Reports (Crunkleton, et al., 2013; Crunkleton, et al., 2012; Crunkleton, et al., 2011; Crunkleton, et al., 2010; Victoria, et al., 2011). Specific information regarding the sampling and analysis methods, including the standard operating procedures (SOPs), can be found in the Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program (Hill et al., 2010) and the Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program (Hill et al., 2011).

The Upper Patuxent watershed is made up of three PSUs: Upper Patuxent, Middle Patuxent, and Stocketts Run. Ten sampling sites were sampled in each of these PSUs in each round of sampling.

Following these procedures, the County is collecting several parameters related to water clarity and sediment deposition at each site.

- Water Quality Measures and Observations
    - Turbidity (measured), observations of general water clarity and color
- Biological Measures
    - Benthic macroinvertebrates (BIBI)
- Habitat Measures
    - General: bar formation and substrate, presence/absence of substrate type
    - PHI: epibenthic substrate, instream habitat

  - RBP: epifaunal substrate / available cover, pool substrate characterization, sediment deposition, channel alteration
- Geomorphic Measures
  - Particle size analysis using modified Wolman pebble counts at 10 transects proportioned by channel bed features

4.1.3 Results

The Upper Patuxent watershed is made up of three PSUs: Upper Patuxent, Middle Patuxent, and Stocketts Run. Stocketts Run is the only PSU completed thus far in Round 3. Upper Patuxent and Middle Patuxent PSUs are both scheduled to be completed in 2019. Results summarized at the PSU scale with mean BIBI and habitat ratings (PHI and RBP) are presented in Table 9.

Table 9: Countywide Biological Monitoring Results

PSU Name	Round	PSU Code	Year Sampled	Drainage Area (acres)	BIBI Rating	PHI Rating	RBP Rating
Upper Patuxent	1	16	2007	6,957	P	PD	PS
Upper Patuxent	2	16	2011	6,957	P	MD	S
Middle Patuxent	1	18	2004	6,332	P	PD	S
Middle Patuxent	2	18	2010	6,332	F	PD	PS
Stocketts Run	1	19	2005	8,714	F	PD	PS
Stocketts Run	2	19	2013	8,714	P	PD	PS
Stocketts Run	3	19	2018	8,714	P	PD	PS

BIBI Ratings: G = Good, F = Fair, P = Poor, VP = Very Poor
PHI Ratings: MD = Minimally Degraded, PD = Partially Degraded, D = Degraded, SD = Severely Degraded
RBP Ratings: C = Comparable, S = Supporting, PS = Partially Supporting, NS = Non-Supporting

4.1.3.1 Biological

During Round 1, biological sampling was completed in 2004 (Middle Patuxent), 2005 (Stocketts Run) and 2007 (Upper Patuxent). Results of the Round 1 sampling effort are presented in Table 10. BIBI narrative condition ratings are presented in Figure 3 for the Upper Patuxent PSU and Figure 4 for the Middle Patuxent and Stocketts Run PSUs. Overall, 43% of the sites in the watershed were rated as "Poor," 33% rated "Fair," 13% rated "Good," and 10% rated "Very Poor." Stocketts Run received the highest average BIBI score of all PSUs during Round 1, with a mean BIBI score of 3.51 ± 0.87 and a corresponding biological condition rating of "Fair." Both Middle Patuxent and Upper Patuxent PSUs received "Poor" biological condition ratings, with mean BIBI scores of 2.94 ±0.71 and 2.37 ±0.38, respectively.

During Round 2, biological sampling was completed in 2010 (Middle Patuxent), 2011 (Upper Patuxent), and 2013 (Stocketts Run). Results of the Round 2 sampling effort are presented in Table 11. Overall, 43% of the sites in the watershed were rated as "Poor," 37% rated "Fair," 3% rated "Good," and 17% rated "Very Poor." Middle Patuxent received the highest average BIBI score of all PSUs during Round 2, with a mean BIBI score of 3.32 ± 0.58 and a corresponding biological condition rating of "Fair." Both Stocketts Run and Upper Patuxent PSUs received "Poor" biological condition ratings, with mean BIBI scores of 2.60 ±0.91 and 2.34 ±0.50, respectively.

Table 10: BIBI Data for Round 1 (2004-2008)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
16-01	2007	18	3	0.0	0	35.3	0	8.4	2.71	Poor
16-02	2007	21	0	0.0	0	50.6	0	3.5	2.14	Poor
16-03	2007	17	2	0.0	0	3.8	0	1.0	1.86	Very Poor
16-05	2007	19	4	0.0	0	40.2	0	13.1	2.71	Poor
16-10	2007	27	0	0.0	0	14.9	0	1.8	2.14	Poor
16-11A	2007	23	2	0.0	0	49.6	0	10.6	3.00	Fair
16-12A	2007	22	0	0.0	0	0.0	0	5.4	1.86	Very Poor
16-13A	2007	16	0	0.0	0	43.6	1	6.8	2.43	Poor
16-14A	2007	20	4	0.0	0	62.5	0	1.9	2.43	Poor
16-16A	2007	31	4	0.0	0	27.8	0	6.5	2.43	Poor
18-02	2004	23	6	0.0	0	25.0	1	13.4	3.29	Fair
18-03	2004	25	1	0.0	0	2.2	1	8.9	2.43	Poor
18-04	2004	26	4	1.0	1	2.9	2	13.7	3.57	Fair
18-05	2004	9	3	0.0	0	4.7	0	2.8	1.57	Very Poor
18-06	2004	20	2	0.0	0	5.4	1	20.4	2.43	Poor
18-07	2004	26	3	0.0	0	5.0	2	8.3	3.00	Fair
18-09	2004	23	3	0.0	0	2.3	1	10.2	2.71	Poor
18-11A	2004	23	6	1.0	1	8.0	0	18.0	3.29	Fair
18-12A	2004	18	5	0.0	0	4.1	2	19.6	3.00	Fair
18-20A	2004	23	5	1.1	1	50.5	1	10.5	4.14	Good
19-01	2005	24	9	16.5	2	54.6	2	4.1	4.71	Good
19-02	2005	21	4	0.0	0	23.5	2	7.8	2.71	Poor
19-03	2005	17	6	0.0	0	29.7	2	10.9	3.57	Fair
19-04	2005	21	4	0.0	0	24.5	1	24.5	2.71	Poor
19-05	2005	15	2	0.0	0	10.1	1	5.1	2.43	Poor
19-06	2005	23	3	0.0	0	32.0	1	6.2	3.00	Fair
19-07	2005	18	4	0.0	0	13.1	2	38.1	3.00	Fair
19-08	2005	26	5	0.0	0	32.7	2	13.9	3.86	Fair
19-09	2005	27	9	12.6	2	53.7	1	12.6	4.71	Good
19-10	2005	26	9	20.4	3	28.6	0	8.2	4.43	Good

Table 11: BIBI Data for Round 2 (2009-2013)

Site ID	Year	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
16-01	2011	19	1	0.0	0	34.7	0	6.9	2.14	Poor
16-03	2011	17	3	0.0	0	72.5	1	0.9	2.71	Poor
16-04	2011	20	2	0.0	0	12.2	0	4.3	2.14	Poor
16-05	2011	11	0	0.0	0	2.9	0	16.2	1.57	Very Poor
16-06	2011	19	4	0.0	0	50.5	0	1.8	2.43	Poor
16-08	2011	26	6	0.0	0	61.3	0	0.9	3.00	Fair
16-09	2011	10	1	0.0	0	31.3	0	1.0	1.86	Very Poor
16-11A	2011	10	4	0.0	0	90.8	0	0.0	1.86	Very Poor
16-12A	2011	12	5	0.0	0	69.4	1	1.8	2.71	Poor
16-15A	2011	19	3	0.0	0	67.3	3	2.9	3.00	Fair
18-02	2010	32	3	0.0	0	6.1	1	11.4	2.71	Poor
18-03	2010	32	10	1.9	1	36.9	1	5.8	3.86	Fair
18-04	2010	26	5	0.0	0	18.1	1	3.4	3.00	Fair
18-05	2010	21	4	0.0	0	52.7	2	10.0	3.29	Fair
18-06	2010	18	6	0.8	1	11.0	1	5.1	3.29	Fair
18-07	2010	34	6	0.0	0	16.8	3	2.8	3.29	Fair
18-08	2010	28	4	0.0	0	22.3	0	16.5	2.71	Poor
18-09	2010	34	10	1.7	2	39.8	3	5.9	4.43	Good
18-10	2010	21	6	0.0	0	49.2	0	7.5	2.71	Poor
18-11A	2010	27	5	0.8	1	20.8	2	5.0	3.86	Fair
19-02	2013	21	3	0.0	0	9.6	4	7.8	2.43	Poor
19-03	2013	13	2	0.0	0	8.6	2	1.0	2.14	Poor
19-04	2013	17	4	0.0	0	11.6	3	1.1	2.71	Poor
19-05	2013	11	1	0.0	0	1.8	1	0.0	1.29	Very Poor
19-06	2013	20	6	9.4	2	26.0	4	3.1	3.86	Fair
19-07	2013	11	5	1.0	1	8.3	1	0.0	2.43	Poor
19-08	2013	15	6	12.5	4	14.4	1	1.0	3.86	Fair
19-10	2013	15	0	0.0	0	5.9	0	2.0	1.57	Very Poor
19-11A	2013	22	4	2.0	2	8.9	4	5.9	3.57	Fair
19-16A	2013	11	3	0.0	0	12.1	1	1.0	2.14	Poor

During Round 3, biological sampling was completed in 2018 for Stocketts Run. Upper Patuxent and Middle Patuxent PSUs are not scheduled for sampling until 2019. Results of the Round 3 sampling effort through 2018 are presented in Table 12. Stocketts Run received a mean BIBI score of 3.11 ± 1.18 and a corresponding biological condition rating of "Fair."

Table 12: BIBI Data for Round 3 (2018)

Site ID	Number of Taxa	Number of EPT Taxa	Percent Ephemeroptera	No. of Ephemeroptera Taxa	Percent Intolerant Urban	Number Scraper Taxa	Percent Climbers	BIBI	Rating
19-L2M-01-18	22	6	10.1	2	19.3	5	29.4	4.43	Good
19-R3M-01-18	15	1	0.0	0	0.0	1	10.9	2.14	Poor
19-R3M-03-18	17	0	0.0	0	1.8	0	5.5	1.57	Very Poor
19-R3M-06-18	17	2	0.0	0	4.5	1	10.9	2.43	Poor
19-L2M-07-18	17	1	0.0	0	1.8	1	9.0	2.14	Poor
19-R3M-07-18	23	3	8.3	1	10.1	1	15.6	3.57	Fair
19-L1M-03-18	25	8	13.3	2	22.5	4	34.2	4.71	Good
19-L1M-01-18	20	6	8.7	2	12.6	1	20.4	3.86	Fair

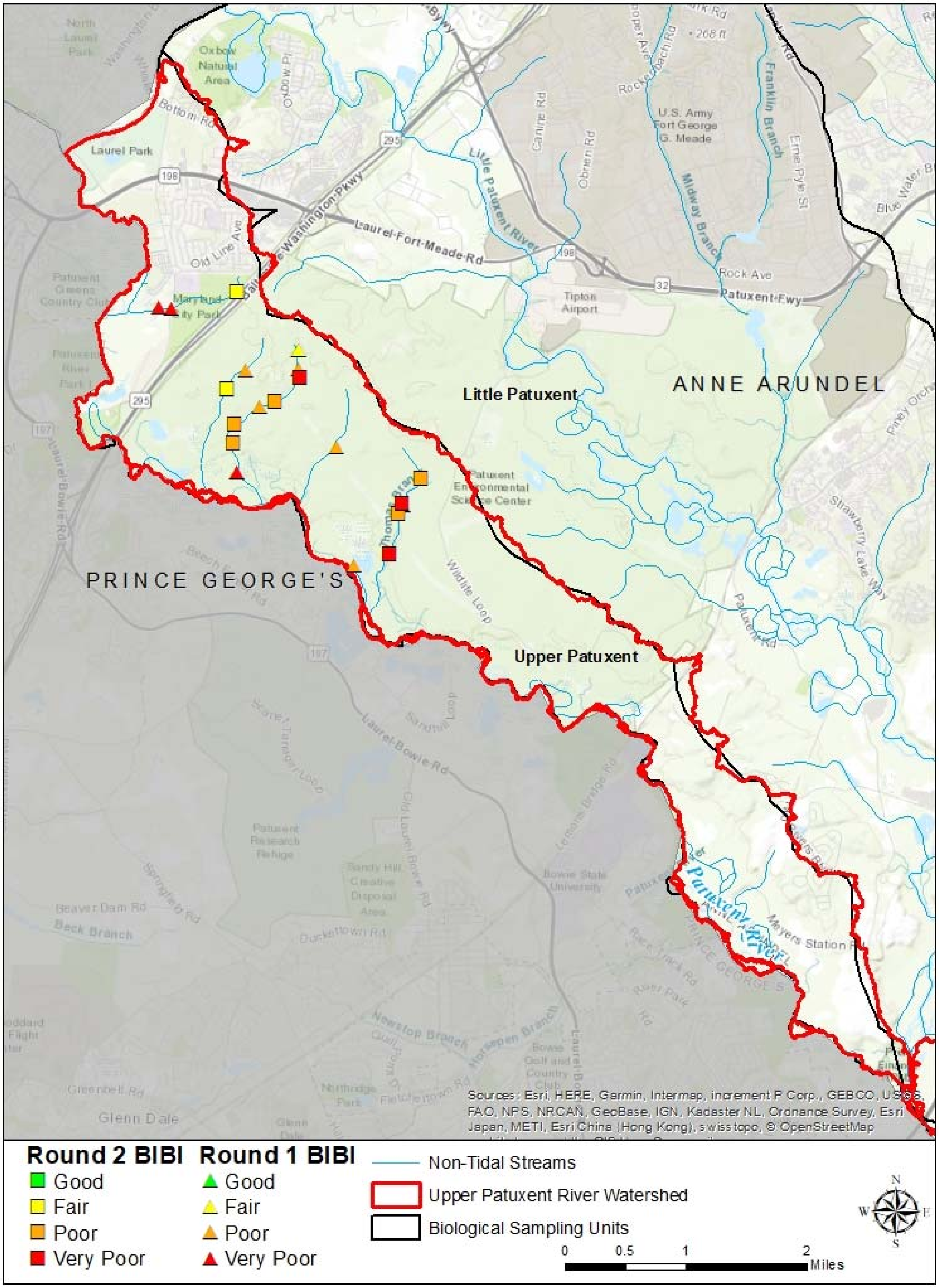

Figure 3: Biological Sampling Results in the Upper Patuxent PSU (2004 - 2018).

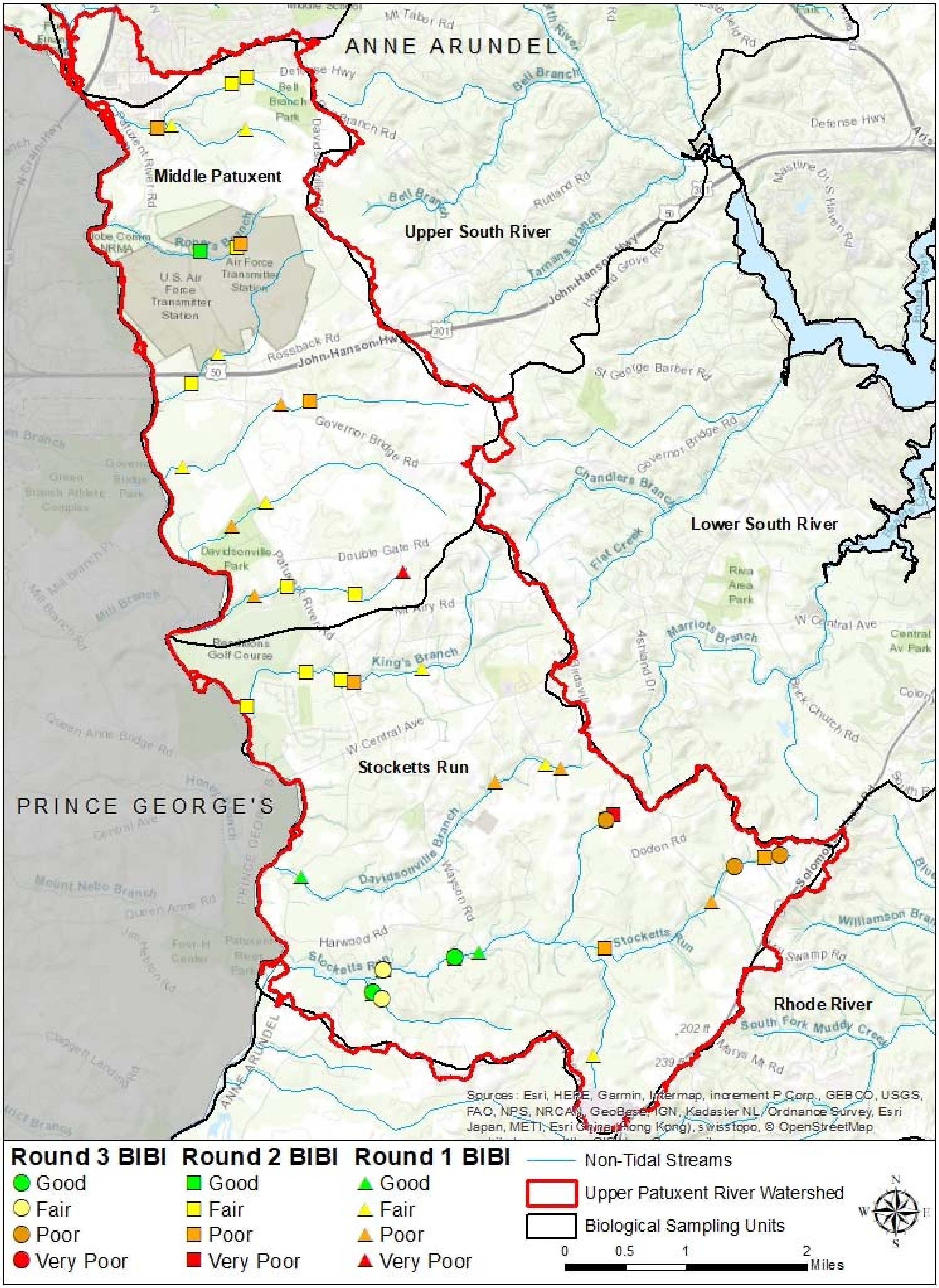

Figure 4: Biological Sampling Results in the Middle Patuxent and Stocketts Run PSU (2004 - 2018).

4.1.3.2 Physical Habitat

Physical habitat assessments during Round 1 were performed concurrently with the biological assessments. Results of the Round 1 habitat assessments are presented in Table 13. MPHI narrative condition ratings are presented in Figure 5 for the Upper Patuxent PSU and Figure 6 for the Middle Patuxent and Stocketts Run PSUs. The MPHI rated 50% of sites “Partially Degraded,” 30% as “Minimally Degraded,” 17% “Degraded” and 3% “Severely Degraded.” All three PSUs received a narrative habitat condition rating of “Partially Degraded” during Round 1. The Middle Patuxent PSU received the highest mean MPHI score of 79.15 ± 6.68, followed by Upper Patuxent (75.88 ± 12.97) and Stocketts Run (68.99 ± 10.12).

Table 13: Physical Habitat Index Data from Round 1 (2004-2008).

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
16-01	2007	75.39	100.00	56.19	86.94	84.77	70.71	79.00	Partially Degraded
16-02	2007	75.39	100.00	66.59	85.02	76.74	63.25	77.83	Partially Degraded
16-03	2007	0.00	49.95	53.86	61.08	62.97	77.46	50.89	Severely Degraded
16-05	2007	26.93	78.67	90.58	100.00	78.04	77.46	75.28	Partially Degraded
16-10	2007	80.78	100.00	44.29	69.85	99.08	70.71	77.45	Partially Degraded
16-11A	2007	80.78	100.00	84.10	100.00	100.00	74.16	89.84	Minimally Degraded
16-12A	2007	10.77	84.56	47.90	60.84	71.58	54.77	55.07	Degraded
16-13A	2007	86.16	100.00	34.72	97.23	83.66	89.45	81.87	Minimally Degraded
16-14A	2007	80.78	100.00	91.12	100.00	83.16	74.16	88.20	Minimally Degraded
16-16A	2007	80.78	100.00	69.71	100.00	95.21	54.77	83.41	Minimally Degraded
18-02	2004	75.39	99.94	86.00	73.46	55.29	67.08	76.19	Partially Degraded
18-03	2004	53.85	99.94	89.33	91.76	59.86	83.67	79.73	Partially Degraded
18-04	2004	86.16	100.00	85.23	79.77	52.73	100.00	83.98	Minimally Degraded
18-05	2004	26.93	91.34	57.56	81.57	79.50	100.00	72.82	Partially Degraded
18-06	2004	96.93	100.00	100.00	100.00	55.50	100.00	92.07	Minimally Degraded
18-07	2004	43.08	78.67	50.00	86.34	78.20	80.63	69.49	Partially Degraded
18-09	2004	37.70	78.67	100.00	100.00	67.65	74.16	76.36	Partially Degraded
18-11A	2004	53.85	100.00	100.00	100.00	65.03	89.45	84.72	Minimally Degraded
18-12A	2004	64.62	78.67	100.00	100.00	63.45	83.67	81.74	Minimally Degraded
18-20A	2004	75.39	99.94	75.75	60.93	50.53	83.67	74.37	Partially Degraded
19-01	2005	42.39	78.67	84.81	79.10	72.70	77.46	72.52	Partially Degraded
19-02	2005	80.05	63.55	84.74	77.02	73.80	82.67	76.97	Partially Degraded
19-03	2005	45.82	49.95	40.87	45.86	100.00	78.00	60.08	Degraded
19-04	2005	59.13	78.67	31.74	31.51	96.23	79.06	62.72	Degraded
19-05	2005	73.92	68.32	47.01	46.37	94.91	80.63	68.53	Partially Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
19-06	2005	81.26	78.67	58.49	31.48	63.87	70.71	64.08	Degraded
19-07	2005	71.68	84.56	100.00	100.00	99.77	95.31	91.89	Minimally Degraded
19-08	2005	59.13	68.32	76.15	72.66	60.10	84.66	70.17	Partially Degraded
19-09	2005	37.50	78.67	66.70	68.90	61.42	89.45	67.10	Partially Degraded
19-10	2005	28.28	58.94	44.12	75.49	50.74	77.46	55.84	Degraded

Results of the Round 2 habitat assessments are presented in Table 14. The MPHI rated 57% of sites "Partially Degraded," 30% as "Minimally Degraded," and 13% as "Degraded." There were no sites rated "Severely Degraded" in Round 2. Upper Patuxent received the highest average MPHI score of all PSUs during Round 2, with a mean MPHI score of 85.3 ± 6.3 and a corresponding narrative rating of "Minimally Degraded." Both Middle Patuxent and Stocketts Run PSUs received "Partially Degraded" narrative ratings, with mean MPHI scores of 75.0 ± 10.4 and 68.0 ± 5.6, respectively.

Table 14: Physical Habitat Index Data from Round 2 (2009-2013).

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
16-01	2011	100.0	91.34	91.04	98.02	75.88	100.0	92.7	Minimally Degraded
16-03	2011	100.0	99.94	94.31	88.47	65.55	86.61	89.1	Minimally Degraded
16-04	2011	80.78	99.94	59.60	68.12	91.91	63.25	77.2	Partially Degraded
16-05	2011	100.0	73.32	81.46	86.54	84.12	100.0	87.5	Minimally Degraded
16-06	2011	96.93	99.94	82.44	82.53	68.07	86.61	86.0	Minimally Degraded
16-08	2011	75.39	99.94	100.0	94.61	66.20	70.71	84.4	Minimally Degraded
16-09	2011	100.0	99.94	97.10	92.86	82.23	100.0	95.3	Minimally Degraded
16-11A	2011	80.78	91.34	88.26	86.14	72.28	83.67	83.7	Minimally Degraded
16-12A	2011	32.31	99.94	85.36	81.58	82.03	77.46	76.4	Partially Degraded
16-15A	2011	37.70	99.94	88.24	93.26	89.47	70.71	79.8	Partially Degraded
18-02	2010	80.78	91.34	77.32	80.04	79.89	74.16	80.5	Partially Degraded
18-03	2010	43.08	91.34	69.95	72.04	83.08	59.16	69.7	Partially Degraded
18-04	2010	86.16	99.94	67.05	63.55	71.62	77.46	77.6	Partially Degraded
18-05	2010	80.78	68.32	68.22	70.93	70.68	83.67	73.7	Partially Degraded
18-06	2010	59.24	91.34	37.43	36.87	54.60	31.62	51.8	Degraded
18-07	2010	53.85	91.34	88.98	83.69	78.22	77.46	78.9	Partially Degraded
18-08	2010	86.16	99.94	61.33	58.14	77.69	74.16	76.2	Partially Degraded

Station	Year	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
18-09	2010	86.16	99.94	100.0	94.70	92.93	63.25	89.5	Minimally Degraded
18-10	2010	53.85	91.34	64.64	56.18	51.42	89.45	67.8	Partially Degraded
18-11A	2010	59.24	99.94	96.20	85.89	89.53	74.16	84.1	Minimally Degraded
19-02	2013	64.62	84.56	48.66	48.97	83.00	31.62	60.2	Degraded
19-03	2013	86.16	84.56	72.68	67.20	54.07	54.77	69.9	Partially Degraded
19-04	2013	70.01	84.56	79.68	69.07	73.88	77.46	75.7	Partially Degraded
19-05	2013	64.62	84.56	64.21	66.25	95.75	31.62	67.8	Partially Degraded
19-06	2013	64.62	91.34	78.73	73.13	54.49	70.71	72.1	Partially Degraded
19-07	2013	59.24	68.32	78.86	69.75	77.16	63.25	69.4	Partially Degraded
19-08	2013	26.93	49.95	77.88	66.24	64.84	77.46	60.5	Degraded
19-10	2013	70.01	49.95	67.76	62.69	100.0	70.71	70.1	Partially Degraded
19-11A	2013	26.93	63.55	79.21	68.33	55.32	70.71	60.6	Degraded
19-16A	2013	75.39	78.67	78.27	68.83	79.09	59.16	73.2	Partially Degraded

Results of the Round 3 habitat assessments are presented in Table 15. During Round 3, Stocketts Run received a “Partially Degraded” narrative rating with a mean MPHI score of 71.77 ± 6.26.

Table 15: Physical Habitat Index Data from Round 3 (2018).

Station	Remoteness Score	Percent Shading	Epifaunal Substrate	Instream Habitat	# Woody Debris/Rootwads	Bank Stability	PHI	Narrative Rating
19-L1M-01-18	51.66	68.32	100.0	85.42	61.28	73.03	73.28	Partially Degraded
19-L1M-03-18	78.93	91.34	92.81	75.02	100.0	91.65	88.29	Minimally Degraded
19-L2M-01-18	35.86	73.32	100.0	91.93	71.22	85.44	76.30	Partially Degraded
19-L2M-07-18	78.21	78.67	69.35	65.19	100.0	91.84	80.54	Partially Degraded
19-R3M-01-18	56.27	45.47	61.00	68.71	100.0	62.05	65.58	Degraded
19-R3M-03-18	54.93	91.34	67.30	78.61	100.0	80.42	78.77	Partially Degraded
19-R3M-06-18	50.84	84.56	83.96	55.22	83.77	49.33	67.95	Partially Degraded
19-R3M-07-18	94.87	84.56	75.66	86.57	81.18	87.47	85.05	Minimally Degraded

4.1.1 Conclusions

At the completion of Round 2, analyses were performed to compare statistical differences between mean index values (i.e., BIBI, PHI) from two time periods (e.g., Round 1 and Round 2) to determine if any changes in PSU scores were statistically significant. The report authors used the method recommended by

Schenker and Gentleman (2001), which is the same method used by the MBSS to evaluate changes in condition over time, and is considered a more robust test than the commonly used method, which examines the overlap between the associated confidence intervals around two means (Hill et. al, 2014). Only one PSU, Stocketts Run, saw a statistically significant change in mean BIBI scores between Round 1 (3.51) and Round 2 (2.60), resulting in a downgrade in biological condition from "Fair" to "Poor." As noted in the Round 2 Report (Hill et al. 2014), there were no significant differences in either RBP or MPHI habitat scores in Stocketts Run, suggesting that the observed changes were not the result of degraded physical habitat conditions. However, statistically significant differences were observed in conductivity values for Stocketts Run between sampling rounds. Stocketts Run saw mean conductivity values jump from 171.40 µS/cm in Round 1 (2005) to 242.73 µS/cm in Round 2 (2013). This suggests increases in conductivity support the notion that changing water quality conditions are most likely responsible for the observed shift in biological conditions observed in this PSU. Since there we no statistically significant differences in the percentage of impervious surface or drainage area to each sampling location, the changes in water quality conditions are not likely attributed to changes in land use between rounds. It is plausible that differences in salt usage for roadway de-icing between sampling years may be responsible for the observed differences in stream conductivity, and subsequently decreased BIBI scores. However, results of Round 3 sampling in Stocketts Run showed an improvement in the mean BIBI score that resulted in an increase back up to a 'Fair' biological condition, although it was not considered a statistically significant increase.

4.2 Targeted Restoration Monitoring Program

In addition to the Countywide Program, the County implements a targeted biological monitoring program. This program utilizes the same techniques and procedures as use in the Countywide Program, but the sites are not randomly selected. There are two general approaches to site selection in the targeted work. First, the County samples a collection of long term sites every year, the number of which has varied over the years. Currently, there are 13 sites in the program, 12 of which are past or proposed stream restoration sites that the County tracks to see how the stream insect community has changed, or will change, over time while one site is a minimally disturbed stream reach that is used as a reference reach. Most of the sites in this group have only been monitored post-restoration. The latest summary report can be found here:
https://www.aacounty.org/departments/public-works/wprp/ecological-assessment-and-evaluation/2016%20Targeted%20Site%20Summary%20Report_Final.pdf

The other group of sites, varying in number from year to year, is established on reaches planned for future restoration work. The intent is to create a baseline of biological conditions to justify project implementation by providing permitting agencies evidence that biological and habitat impairments exist within a reach of interest.

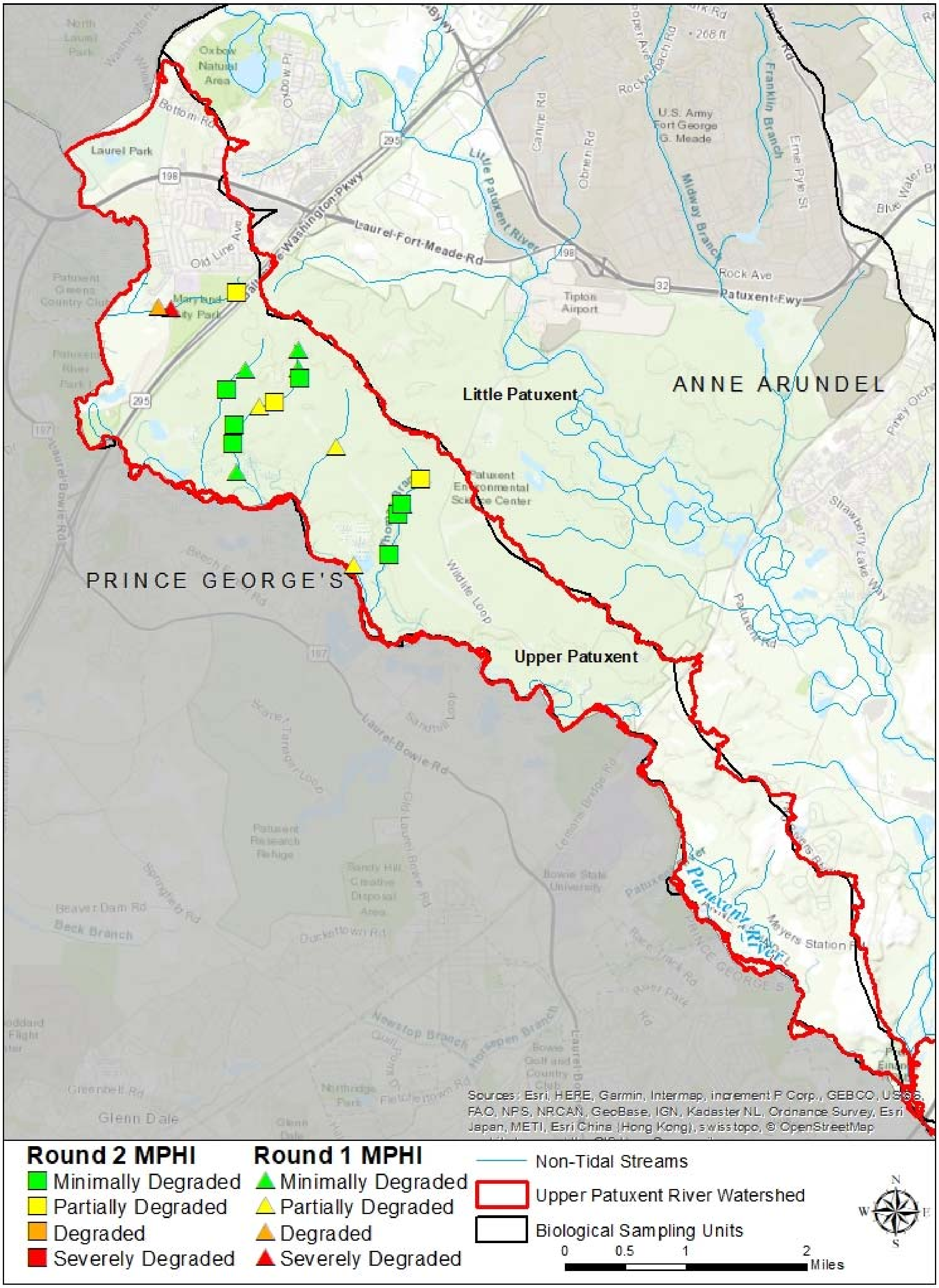

Figure 5: Physical Habitat Assessment Results in the Upper Patuxent PSU (2004 - 2018).

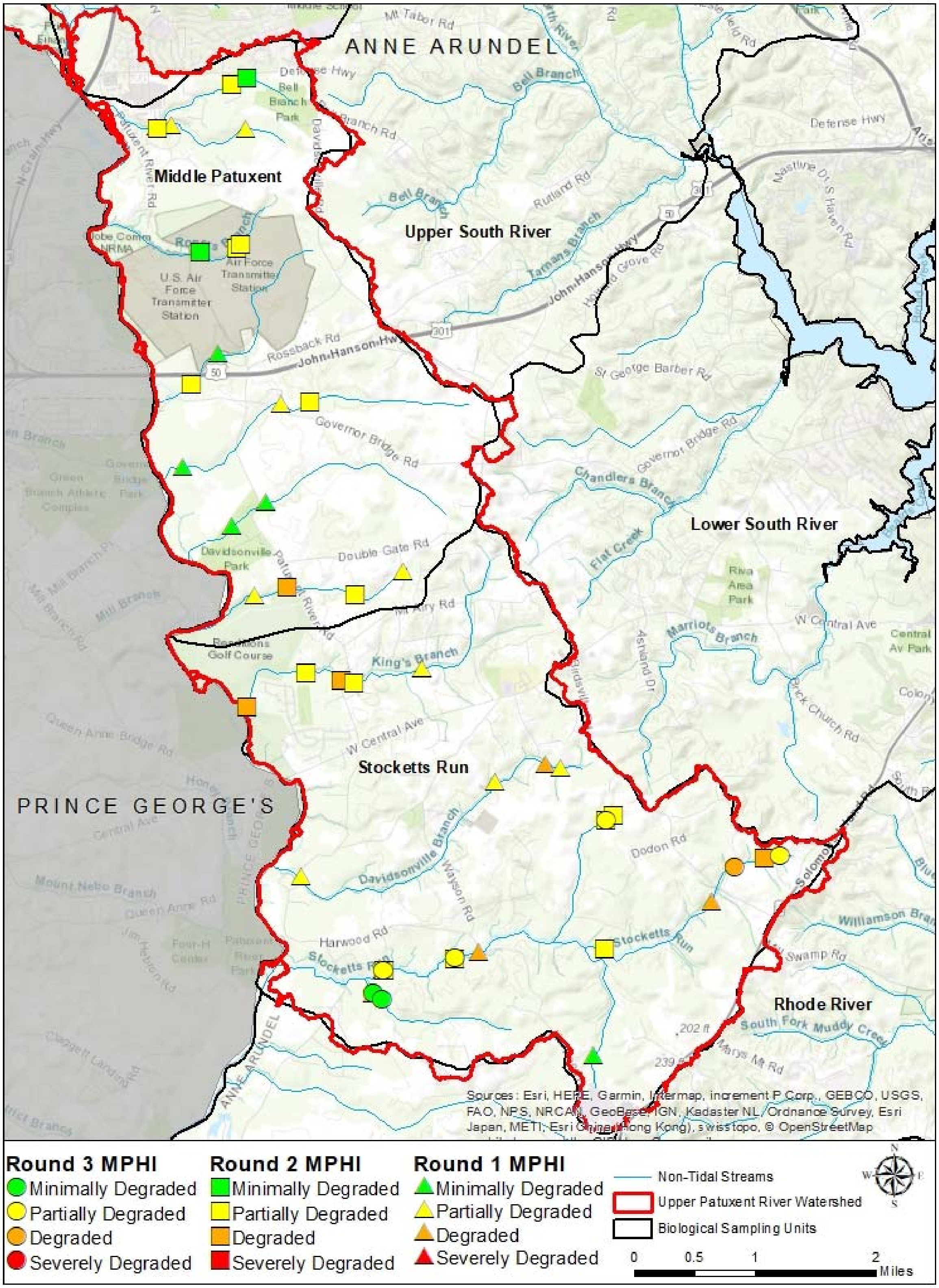

Figure 6: Physical Habitat Assessment Results in the Middle Patuxent and Stocketts Run PSUs (2004 - 2018).

5 Conclusion

This Upper Patuxent River TMDL Annual Assessment report documents the progress achieved through the end of fiscal year 2018. The assessment includes a report on project and program implementation completed in the current report year and cumulatively through FY2018. The report summarizes the modeled and calculated pollutant load reductions and loads achieved through the implemented programs. Further, the report compares the implementation levels and load reductions against the overall goals, specifically the SW-WLA, and the planned milestone targets as outline in the 2016 plan (Anne Arundel County, 2016).

Anne Arundel County spent $12,654 dollars in FY2018 in operational costs in the Upper Patuxent watershed. With those funds, the County is implementing programmatic practices including inlet cleaning and street sweeping. Load reductions are at 7.2% on a total goal of 11.4% and the County is on track to meet the load reduction with planned projects before the 2025 date set in the County's plan. Biological stream monitoring data thus far with two rounds completed, and a third underway, indicates a watershed that is in fair to poor biological health. The remaining Upper Patuxent River PSUs (Upper Patuxent and Middle Patuxent) are scheduled to be monitored again in 2019, which once completed will provide a check on overall biological condition trends.

The MAST modeling tool currently used to track the County's progress toward meeting the Upper Patuxent River Sediment TMDL will be replaced by the CAST tool in 2019. Progress reported for the next period, FY2019, will be modeled using CAST and Phase 6 Bay model. We anticipate that differences will be observed after modeling FY2019 implementation that reflect changes between the P5.3.2 and P6 Bay models and not actual changes to loads on the ground.

6 References

Anne Arundel County, Department of Public Works. 2015. FY15 Enhanced Street Sweeping Program. Annapolis, MD.

Anne Arundel County, 2016. Upper Patuxent River Sediment TMDL Restoration Plan. Prepared by KCI Technologies for the Anne Arundel County Department of Public Works, Annapolis MD.

CBP, 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices, Final Report, May 19, 2016. Chesapeake Bay Program, Annapolis, MD.

Crunkleton, M.C., C. R.Hill, and M.J. Pieper. 2010. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2010. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 52 pp., plus Appendices.

Crunkleton, M.C., C. R.Hill, and M.J. Pieper. 2011. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2011. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 51 pp., plus Appendices.

Crunkleton, M.C., C. R.Hill, and M.J. Pieper. 2012. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2012. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 50 pp., plus Appendices.

Crunkleton, M.C., C. R.Hill, and M.J. Pieper. 2013. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2013. Anne Arundel County Department of Public Works, Watershed, Ecosystem, and Restoration Services, Annapolis, Maryland. 54 pp., plus Appendices.

DNR. 2007. Maryland Biological Stream Survey Sampling Manual: Field Protocols. CBWP-MANTA-EA-07-01. Published by the Maryland Department of Natural Resources, Annapolis, MD. Publication # 12-2162007-190.

Hill, C.R., and M. J. Pieper. 2010. Documentation of Method Performance Characteristics for the Anne Arundel County Biological Monitoring Program. Revised, December 2010. Prepared by KCI Technologies, Sparks, MD for Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Hill, C.R., and M. J. Pieper. 2011. Quality Assurance Project Plan for Anne Arundel County Biological Monitoring and Assessment Program. Revised, May 2011. Prepared by KCI Technologies, Sparks, MD for Anne Arundel County, Department of Public Works, Watershed, Ecosystem, and Restoration Services. Annapolis, MD.

Kazyak, P.F. 2001. Maryland Biological Stream Survey Sampling Manual. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis, MD.

MDE. Code of Maryland Regulations (COMAR). Continuously updated. Code of Maryland Regulations, Title 26- Department of the Environment. 26.08.02.01- Water Quality.

MDE. 2010. Watershed Report for Biological Impairment of the Patuxent River Upper Watershed in Anne Arundel, Price Georges, Montgomery, and Howard Counties, Maryland – Biological Stressor Identification Analysis Results and Interpretation. Maryland Department of the Environment, Baltimore, MD. Prepared for Water Protection Division, U.S. Environmental Protection Agency, Region III. Philadelphia, PA.

MDE. 2011. Total Maximum Daily Loads of Sediment in the Patuxent River Upper Watershed, Anne Arundel, Howard and Prince George's Counties, Maryland. Maryland Department of the Environment. Prepared for Water Protection Division, U.S. Environmental Protection Agency, Region III. Baltimore, MD.

MDE. 2012a. Maryland's Final 2012 Integrated Report of Surface Water Quality. Maryland Department of the Environment. Baltimore, MD. Online at: http://www.mde.state.md.us/programs/Water/TMDL/ Integrated303dReports/Pages/2012_IR.aspx

MDE. 2012b. Decision Methodology for Solids for the April 2002 Water Quality Inventory (updated in February of 2012).
http://www.mde.state.md.us/programs/Water/TMDL/Integrated303dReports/Documents/Assessment_Methodologies/AM_Solids_2012.pdf

MDE. 2014a. Maryland's Final 2014 Integrated Report of Surface Water Quality. Maryland Department of the Environment. Baltimore, MD. Online at: http://www.mde.state.md.us/programs/Water/TMDL/ Integrated303dReports/Pages/2014IR.aspx

MDE. 2014b. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated – Guidance for National Pollutant Discharge Elimination System Stormwater Permits. Maryland Department of the Environment. August 2014. Baltimore, MD.

Simpson, T., and S. Weammert. 2009. Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus, and Sediment in the Chesapeake Bay Watershed. December 2009. University of Maryland Mid-Atlantic Water Program.

Southerland, M., G. Rogers, M. Kline, R. Morgan, D. Boward, P. Kazyak, and S. Stranko. 2005. Development of New Fish and Benthic Macroinvertebrate Indices of Biotic Integrity for Maryland Streams. Report to Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources, Annapolis, MD.

Victoria, C., J. Markusic, J. Stribling, and B. Jessup. 2011. Aquatic Biological Assessment of the Watersheds of Anne Arundel County, Maryland: 2009. Prepared by: Anne Arundel County Department of Public Works, Watershed and Ecosystem Services, Annapolis, MD, and Tetra Tech, Inc. Center for Ecological Sciences, Owings Mills, MD.